CISM - SOAC Kickoff Meeting

Low Temperature Electronics

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Outline:

1. **Temperature Range Across the Solar System**
2. **Need for the Low Temperature Electronics (LTE)**
3. **Issues of LTE Circuits.**
4. **Research Directions for Reliable LTE.**

1. Temperature Range Across the Solar System

2. Need for the Low Temperature Electronics

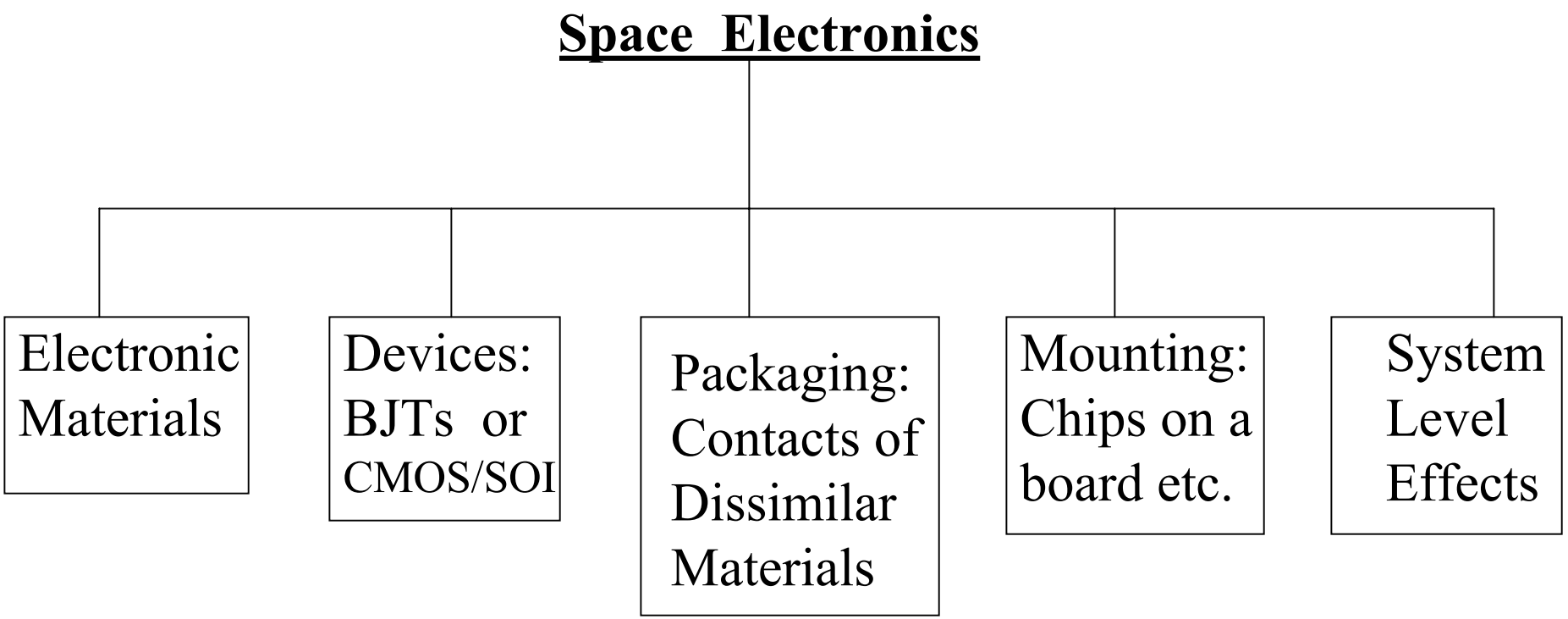
Electronics on board the spacecraft is kept warm for its proper functioning with the heating elements installed as a part of the microelectronics package.

These heating elements consume power which is becoming a more and more valuable commodity in space exploration.

Supply of the sustained power determines the life of the mission

Generally power levels decrease as the mission progresses due to burn up of the fuels, diminishing light intensity and the decreasing efficiency of the solar cells and similar devices due to various reasons

3. Issues of LTE Circuits



Electronics Materials at Low temperatures

Usually Exhibit Enhanced Performance in the Temperature Range of 300 to 150 K because of the increased mobility of charge carriers.

Mobility: Speed with which a charge carrier moves in given material as a result of the application of a unit electric field.

This happens because of the changing of the domination of the scattering mechanisms from phonon related to the ionized impurity dependent as a result of the decreasing amplitude of the lattice sites with temperature.

Devices at Low Temperature

Bipolar devices exhibit some sensitivity to low temperatures in terms of the shift in characteristics, especially during the temperature ramping.

Most FETs made from Si, GaAs, and Ge exhibit adequate to superior performance at low temperatures.

Packaging: Contacts of Dissimilar Materials

Thermal cycling as a result of the variation of temperature in the range of 150 to 300 K cause uneven expansion of the dissimilar materials forming contacts in packaging. The reason being a difference in the coefficients of thermal expansion for such materials.

Thin film structures exhibit enhanced effect under such conditions.

Existing crystal defects and processing induced random structure flaws also get enhanced.

Mounting: Chips on a board etc.

Metal to metal contacts arising from the mounting of chips on a board would also suffer the consequence of thermal cycling because of the difference in the coefficient of thermal expansion.

System Level Effects

Problems resulting from thermal cycling of electronics will reduce the reliability if not addressed properly.

4. Research Directions for Reliable LTE.

1. Design strategies for a stable performance under temperature variations. This includes doping levels, selection of contact materials etc.

2. Testing under rapid thermal cycling conditions.

3. Accelerate testing schemes for long term reliability assurance.

4. Modified testing schemes for shrinking technologies.